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**Chao et al.**

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(54) **ORGANIC LIGHT EMITTING DIODE  
DISPLAY DEVICE AND DISPLAY PANEL  
THEREOF**

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(57) **ABSTRACT**

An organic light emitting diode (OLED) display device and a display panel thereof are provided. The organic light emitting diode display panel comprises a first substrate, a first electrode, an organic light emitting layer, a second electrode, and a second substrate. The first electrode is disposed on the first substrate. The organic light emitting layer is disposed on the first electrode. The second electrode is disposed on the organic light emitting layer. The second substrate is located on the second electrode. The material of the second electrode comprises an alkaline earth element and silver. The second electrode comprises a first portion and a second portion, and the first portion is located between the second portion and the first substrate. The ratios of the alkaline earth element to silver in the first portion and in the second portion are different.

**20 Claims, 5 Drawing Sheets**

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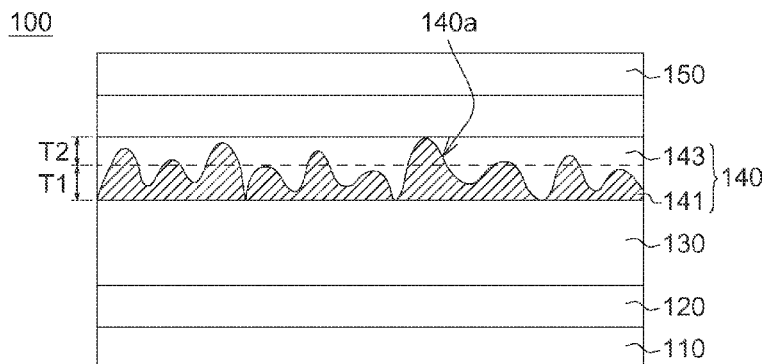
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(58) **Field of Classification Search**  
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USPC ..... 257/40  
See application file for complete search history.



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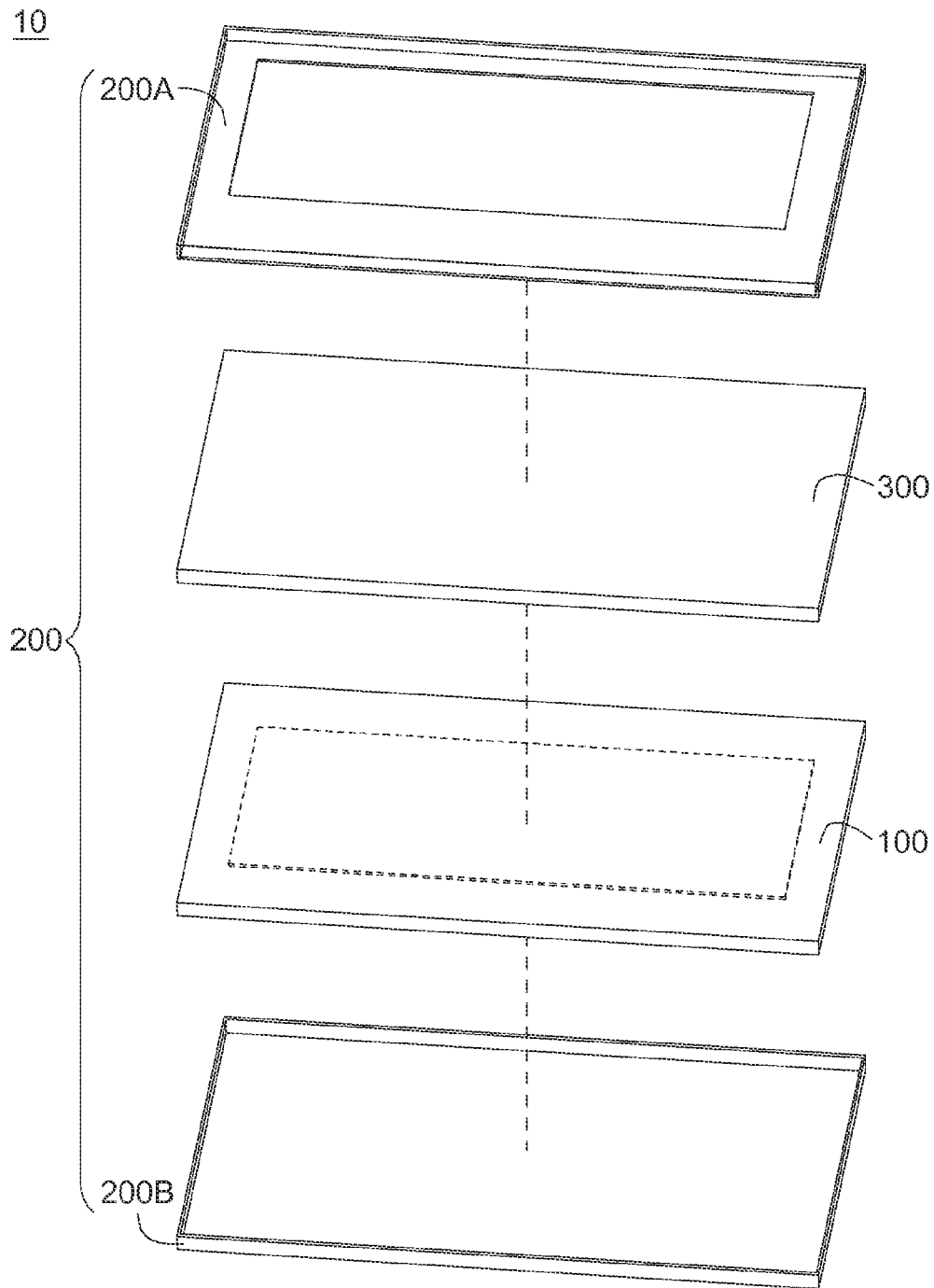


FIG. 1

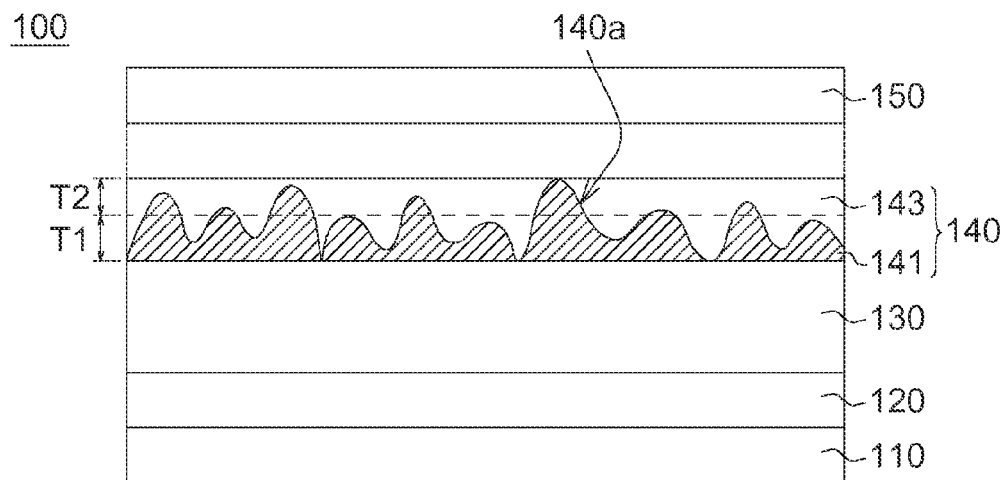


FIG. 2

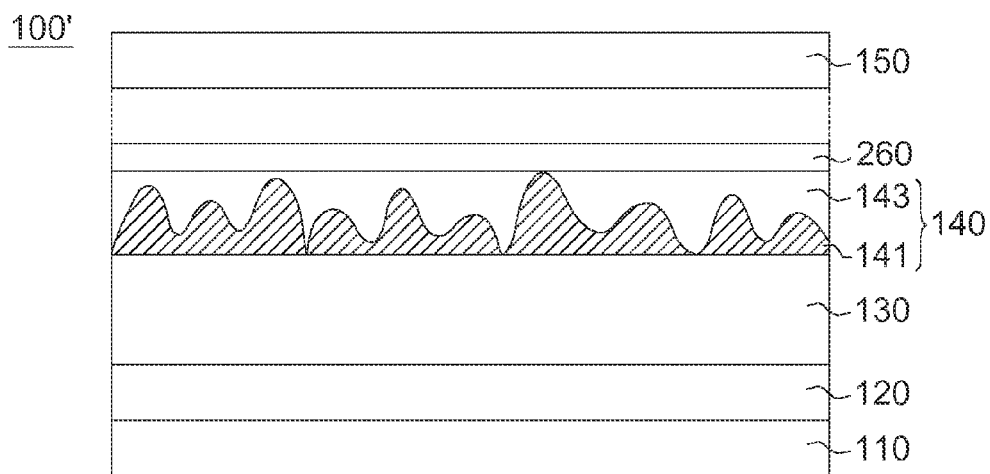


FIG. 3

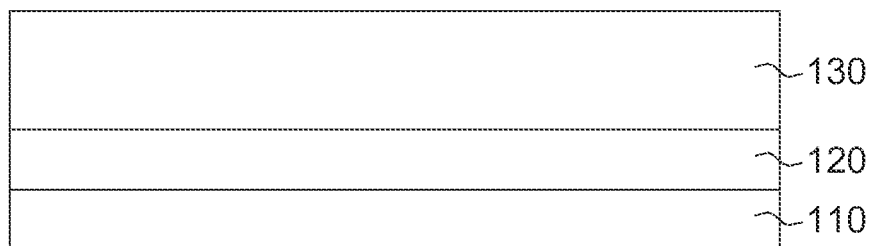


FIG. 4A

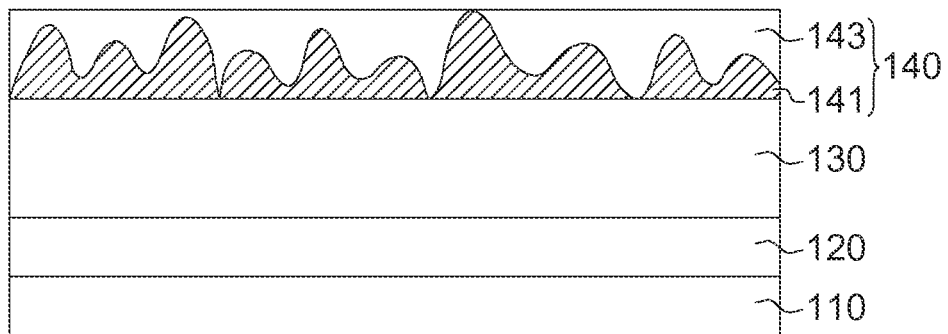


FIG. 4B

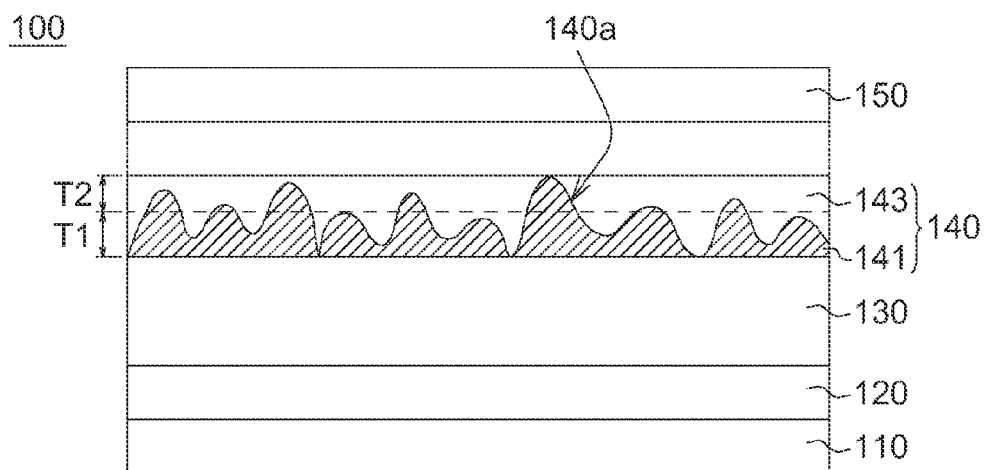


FIG. 4C

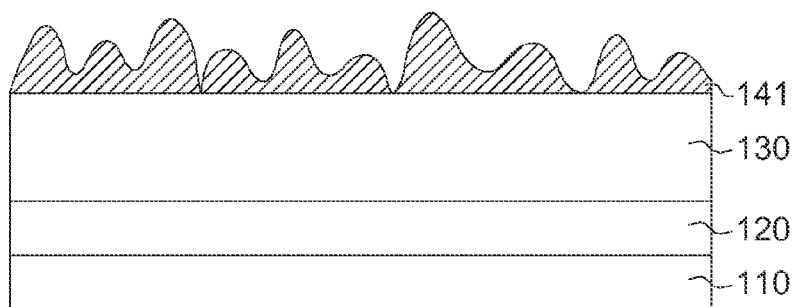


FIG. 5A

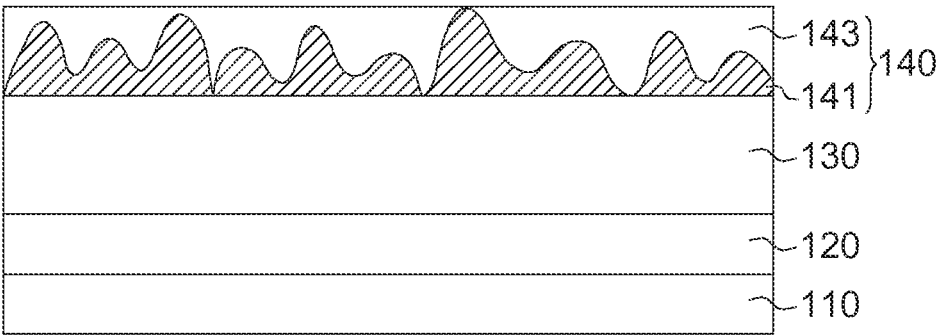


FIG. 5B

1

# ORGANIC LIGHT EMITTING DIODE DISPLAY DEVICE AND DISPLAY PANEL THEREOF

This application claims the benefit of People's Republic of China application Serial No. 201210472034.1, filed Nov. 20, 2012, the subject matter of which is incorporated herein by reference.

## BACKGROUND

### 1. Technical Field

The invention relates in general to an organic light emitting diode display device and a display panel thereof, and particularly to the organic light emitting diode display device and the display panel thereof comprising an electrode having two portions, wherein the ratios of an alkaline earth element to silver in the two portions are different.

### 2. Description of the Related Art

Along with the advances of display technology, various types of display devices have been developed. Organic light emitting diode display devices have become one of the most important research targets of display technology due to light weights, good display properties, and low costs. Therefore, the requirements to the functions and characteristics of organic light emitting diode display devices have gradually increased as well.

Generally, the organic light emitting diode structure of an organic light emitting diode display device is mainly comprised of two electrodes and an organic light emitting layer disposed between the two electrodes. When a voltage is applied on the two electrodes, charge carriers are produced and pass through the organic light emitting layer, and the charge carriers combined produce lights.

However, the electrodes located inside the organic light emitting display device is formed on the light emitting layer made of organic materials. The reliability and luminous efficiency of the whole display device may be influenced due to the poor adhesion between the electrodes and the organic light emitting layer. Therefore, researchers have been working on providing an organic light emitting diode display device with high reliability and great luminous efficiency.

## SUMMARY

The invention relates to an organic light emitting diode display device and a display panel thereof. In the organic light emitting diode display panel, with an electrode having two portions, wherein the ratios of an alkaline earth element to silver in the two portions are different, luminous efficiency can be increased, the adhesion between the electrodes and an organic light emitting layer is improved, and the conductivity of the electrodes are increased.

According to an aspect of the present disclosure, an organic light emitting diode (OLED) display panel is provided. The organic light emitting diode display panel comprises a first substrate, a first electrode, an organic light emitting layer, a second electrode, and a second substrate. The first electrode is disposed on the first substrate. The organic light emitting layer is disposed on the first electrode. The second electrode is disposed on the organic light emitting layer. The second substrate is located on the second electrode. The material of the second electrode comprises an alkaline earth element and silver. The second electrode comprises a first portion and a second portion, and the first portion is located between the

2

second portion and the first substrate. The ratios of the alkaline earth element to silver in the first portion and in the second portion are different.

According to another aspect of the present disclosure, an organic light emitting diode display device is provided. The organic light emitting diode display device comprises a case and an organic light emitting diode display panel. The organic light emitting diode display panel is disposed in the case. The organic light emitting diode display panel comprises a first substrate, a first electrode, an organic light emitting layer, a second electrode, and a second substrate. The first electrode is disposed on the first substrate. The organic light emitting layer is disposed on the first electrode. The second electrode is disposed on the organic light emitting layer. The second substrate is located on the second electrode. The material of the second electrode comprises an alkaline earth element and silver. The second electrode comprises a first portion and a second portion, and the first portion is located between the second portion and the first substrate. The ratios of the alkaline earth element to silver in the first portion and in the second portion are different.

The above and other aspects of the disclosure will become better understood with regard to the following detailed description of the non-limiting embodiment(s). The following description is made with reference to the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows an explosion diagram of an organic light emitting diode display device according to an embodiment of the present disclosure;

FIG. 2 shows a schematic diagram of the organic light emitting display panel according to an embodiment of the present disclosure;

FIG. 3 shows an organic light emitting diode display panel according to another embodiment of the present disclosure;

FIGS. 4A-4C illustrate a process for manufacturing an organic light emitting diode display panel according to an embodiment of the present disclosure; and

FIGS. 5A-5B illustrate a process of an organic light emitting diode display panel according to another embodiment of the present disclosure.

## DETAILED DESCRIPTION

In the embodiments of the present disclosure, an organic light emitting diode display device and a display panel thereof are provided. In the organic light emitting diode display panel, with an electrode having two portions, wherein the ratios of an alkaline earth element to silver in the two portions are different, luminous efficiency can be increased, the adhesion between the electrodes and an organic light emitting layer is improved, and the conductivity of the electrodes are increased. The following embodiments are for the purpose of elaboration only, not for limiting the scope of protection of the invention. Detailed structures and processes may be modified or changed by one skilled in the art after having the benefit of this description of the disclosure.

Referring to FIG. 1, FIG. 1 shows an explosion diagram of an organic light emitting diode display device 10 according to an embodiment of the present disclosure. As shown in FIG. 1, the organic light emitting diode display device 10 comprises an organic light emitting display panel 100, a case 200, and a front plate 300. The organic light emitting display panel 100 is disposed in the case 200. The organic light emitting display panel 100 is connected to driving units (not shown) for receiv-



ing driving signals. The front plate **300** is also disposed in the case **200**. The front plate **300** is located between the organic light emitting display panel **100** and observers. The front plate **300** being a transparent cover plate can provide protection, resistance to pressure, and stain resistance. The front plate **300** can further comprise functional structures, such as touch sensors, or barriers or lens for three-dimensional displaying. In the embodiment, as shown in FIG. 1, the case **200** comprises an upper case **200A** and a lower case **200B**. The organic light emitting display panel **100** and the front plate **300** are disposed between the upper case **200A** and the lower case **200B**. In other embodiments, the front plate **300** can be removed.

Referring to FIG. 2, FIG. 2 shows a schematic diagram of the organic light emitting display panel **100** according to an embodiment of the present disclosure. As shown in FIG. 2, the organic light emitting display panel **100** comprises a first substrate **110**, a first electrode **120**, an organic light emitting layer **130**, a second electrode **140**, and a second substrate **150**. The first electrode **120** regard as anode is disposed on the first substrate **110** and is located between the first substrate **110** and the second substrate **150**. The organic light emitting display panel **100** may further comprise additional structures, such as thin film transistors (TFT), conductive lines, capacitors, dielectric layers, pixel definition layers, and etc., between the first substrate **110** and the first electrode **120**, and the description of those structures and the driving operations thereof are omitted herein. The organic light emitting layer **130** is disposed on the first electrode **120** and is located between the first electrode **120** and the second substrate **150**. The electrodes on two sides of the organic light emitting layer **130** regard as cathode and anode to produce electron-hole pairs with a voltage applied thereon, and the electrons and holes combine in the light emitting layer for emitting lights. The second electrode **140** is disposed on the organic light emitting layer **130** and is located between the organic light emitting layer **130** and the first electrode **120**. There is usually a gap between the second substrate **150** and the second electrode **140**; however, the second substrate **150** and the second electrode **140** can also be contacted to each other. A capping layer (not shown) can further be disposed on the second electrode **140** to fully cover the first electrode **120**, the organic light emitting layer **130**, and the second electrode **140** for preventing water and oxygen from passing through, such that the life of the organic light emitting diodes can be prolonged. The first substrate **110** and the second substrate **150** can be sealed with encapsulating materials, such as frits (not shown) or sealants (not shown) connecting the first substrate **110** and the second substrate **150** for enclosing a space, in which space the organic light emitting diodes are disposed. Further, an optical cement adhesive (OCA, not shown) can be filled in the space and occupy part of the space where the organic light emitting diodes do not occupy, such that chances of the organic light emitting diodes being damaged under pressure are reduced. The materials of the first substrate **110** and the second substrate **150** can be glass, plastics, acrylates, ceramics, metals, or the composite structure thereof. The substrate (either the first substrate **110** or the second substrate **150**) disposed on the light emitting surface needs to be light transmissive.

In the embodiment, the material of the first electrode **120** comprises a transparent conductive material, such as indium tin oxide (ITO), and silver for aluminum), and indium tin oxide and silver form a composite stacked structure, such as ITO-Ag-ITO. In the structure, silver can reduce resistance and can be used as a reflective layer. When the first electrode **120** is located on the light emitting surface, the thickness of

the silver layer needs to be controlled in order for lights to pass through. The material of the second electrode **140** comprises an alkaline earth element and silver (aluminum may apply as well). In this embodiment, the second electrode **140** is located on the light emitting surface; therefore, the thickness of the second electrode needs to be controlled in order for lights to pass through. The second electrode **140** comprises a first portion **141** and a second portion **143**, the ratios of the alkaline earth element to silver in the first portion **141** and in the second portion **143** are different. In the embodiment, as shown in FIG. 2, the first portion **141** of the second electrode **140** is such as located between the second portion **143** of the second electrode **140** and the first substrate **110**. In one embodiment, as shown in FIG. 2, the interface **140a** between the first portion **141** and the second portion **143** has such as an irregular shape. In another embodiment, the interface between the first portion **141** and the second portion **143** can also be flat (not shown), and the first portion **141** and the second portion **143** are two stacked planar films.

In the embodiment, the organic light emitting layer **130** comprises such as electron transport layer (ETL)/electron injection layer (EIL), emission layer (EML), and hole transport layer (HTL)/hole injection layer (HIL). The emission layer is disposed between the electron transport layer/electron injection layer and the hole transport layer/hole injection layer (not shown).

In the embodiment, the material of the electron transport layer and the material of the electron injection layer comprise, for example, BPhen (4,7-diphenyl-1,10-phenanthroline), Liq (8-hydroxyquinolinolato-lithium), BALq (Bis(2-methyl-8-quinolinolato)-4-(phenylphenolato)aluminum), TPBi (2,2',2''-(1,3,5-benzinetriyl)-tris(1-phenyl-1-H-benzimidazole), or the combinations thereof. The material of the electron injection layer further comprises lithium (Li) or cesium (Cs) dopants. In the embodiment, the material of the hole transport layer comprises, such as, NPB (N,N'-bis(naphthalen-1-yl)-N,N'-bis(phenyl)-benzidine), TPD (N,N'-bis(3-methylphenyl)-N,N'-bis(phenyl)-benzidine),  $\alpha$ -NPD (N,N'-bis(naphthalen-1-yl)-N,N'-bis(phenyl)-2,2'-dimethylbenzidine), or the combinations thereof. In the embodiment, the material of the hole injection layer comprises, such as, HAT-CN (Dipyrazino [2,3-f:2',3'-h]quinoxaline-2,3,6,7,10,11-hexacarbonitrile), phthalocyanine copper complex (CuPC), F4-TCNQ (2,3,5,6-tetrafluoro-7,7,8,8-tetracyano-quinodimethane), or the combinations thereof.

In the embodiment, the material of the light emitting layer may comprise fluorescence materials or phosphor materials of red light, green light, or blue light. The red fluorescence material comprises such as a mixture of rubrene and Alq<sub>3</sub> (Tris(8-hydroxy-quinolinato)aluminum) as the host material doped with DCJTb dye (4-(dicyanomethylene)-2-tert-butyl-6-(1,1,7,7-tetramethyljulolidin-4-yl-vinyl)-4H-pyran) as the guest material. The red phosphor material comprises such as CBP (4,4'-bis(carbazol-9-yl)biphenyl) and/or TCTA (4,4',4''-Tris(carbazol-9-yl)triphenylamine) as the host material doped with Ir(piq)<sub>3</sub> (Tris(1-phenylisoquinoline)iridium(III)) and/or Ir(btp)<sub>2</sub>(acac) (Bis(2-benzo[b]thiophen-2-yl-pyridine)(acetylacetonate)iridium(III)) as the guest material. The green fluorescence material comprises such as TPBA (2,2'-bi(9,10-diphenyl-anthracene) as the host material doped with C545T (10-(2-Benzothiazolyl)-2,3,6,7-tetrahydro-11,7,7-tetramethyl-1H,5H,11H-(1)benzopyrroprano(6,7-8-1-j)quinolizin-11-one) as the guest material. The green phosphor material comprises such as CBP (4,4'-bis(carbazol-9-yl)biphenyl) and/or TCTA (4,4',4''-Tris(carbazol-9-yl)triphenylamine) as the host material doped with Ir(ppy)<sub>3</sub> (Tris(2-phenylpyridine)iridium(III)) and/or Ir(ppy)<sub>2</sub>(acac) (Bis(2-

phenylpyridine)(acetylacetonate)iridium(III)) as the guest material. The blue fluorescence material comprises such as MADN (2-methyl-9,10-bis(naphthalen-2-yl)anthracene) as the host material doped with DPVABi (4,4'-bis[4-(di-p-tolylamino)styryl]biphenyl) as the guest material. The blue phosphor material comprises such as MCP (1,3-bis(carbazol-9-yl)benzene) and/or UGH-2 (1,4-bis(triphenylsilyl)benzene) as the host material doped with FIrPic (Bis(3,5-difluoro-2-(2-pyridyl)phenyl)-(2-carboxypyridyl)iridium(III)) and/or FIr<sub>6</sub> (Bis(2,4-difluorophenylpyridinato)tetrakis(1-pyrazolyl)borate iridium(III)) as the guest material.

In the embodiment, the first portion **141** of the second electrode **140** has a first thickness **T1**, and the second portion **143** of the second electrode **140** has a second thickness **T2**. The above-mentioned thicknesses are the average thicknesses of the corresponding portions. The ratio of the first thickness **T1** to the second thickness **T2** is, for example, 1:0.5-1:4.

In an embodiment, the ratio of the alkaline earth element to silver in the first portion **141** is larger than the ratio of the alkaline earth element to silver in the second portion **143**.

In an embodiment, the alkaline earth element is such as magnesium or silver.

In an embodiment, the first portion **141** is formed of magnesium, and the second portion **143** is formed of silver. In another embodiment, the first portion **141** is formed of magnesium, and the second portion **143** is formed from magnesium and silver. In a further embodiment, the first portion **141** is formed from magnesium and silver, and the second portion **143** is formed of silver. In yet another embodiment, the first portion **141** is formed from magnesium and silver, and the second portion **143** is formed from magnesium and silver.

The lowest unoccupied molecular orbital (LUMO) of the electron transport layer/electron injection layer of the organic light emitting layer **130** has a band gap (energy gap) value of 2.5-3.5 eV, the work function of magnesium is 3.46 eV, and the work function of magnesium-silver alloy is about 3.7 eV. In the embodiment, when the ratio of magnesium to the mixture of magnesium and silver in the first portion **141** is larger than that in the second portion **143**, the electron transport layer/electron injection layer of the organic light emitting layer **130** is in direct contact with the first portion **141** of the second electrode **140**, and the work function of magnesium is close to the work function (band gap value) of the electron transport layer/electron injection layer, the magnesium content being relatively high in the first portion **141** is advantageous to the transport or injection of electrons, and hence the luminous efficiency is improved.

In addition, the adhesion between pure magnesium and organic films is poor. In the embodiment, the material of the second electrode **140** comprises magnesium and silver, and the existence of silver is beneficial to the adhesion between the second electrode **140** and the organic light emitting layer **130**. Moreover, when the size of the organic light emitting diode display panel is relatively large, the wave patterns of driving signals from ends of conductive lines tend to decay more quickly. The existence of silver can increase the conductivity of the second electrode **140**, and therefore, the undesired changes of the wave patterns of driving signals are reduced.

In the embodiment, when the first portion **141** is formed from magnesium and silver, the atomic ratio of magnesium to the mixture of magnesium and silver is about between 80% and less than 100% ( $100\% > \text{Mg}/(\text{Mg} + \text{Ag}) \geq 80\%$ ). Preferably, the atomic ratio of magnesium to the mixture of magnesium and silver is about between 90% and less than 100% ( $100\% > \text{Mg}/(\text{Mg} + \text{Ag}) \geq 90\%$ ).

In the embodiment, when the second portion **143** is formed from magnesium and silver, the atomic ratio of magnesium to the mixture of magnesium and silver is about between larger than 0% and 90% ( $90\% \geq \text{Mg}/(\text{Mg} + \text{Ag}) > 0\%$ ). Preferably, the atomic ratio of magnesium to the mixture of magnesium and silver is about between larger than 0% and 80% ( $80\% \geq \text{Mg}/(\text{Mg} + \text{Ag}) > 0\%$ ).

Referring to FIG. 3, FIG. 3 shows an organic light emitting diode display panel **100'** according to another embodiment of the present disclosure. As shown in FIG. 3, the difference between the present embodiment from the embodiment as shown in FIG. 2 is that, the second electrode **140** of the organic light emitting diode display panel **100'** further comprises a third portion **260**. The third portion **260** is located on the second portion **143**. The third portion **260** is located between the second portion **143** and the second substrate **150**. The material of the third portion **260** is silver. In the embodiment, when the first portion **141** and the second portion **143** are both formed from magnesium and silver, the silver in the third portion **260** can enhance the electron transport/injection properties of the whole electrode. When the material of the second portion **143** is silver, the third portion **260** can be optionally omitted. The elements in the present embodiment sharing the same labels with those in the previous embodiments are the same elements, and the description of which is omitted.

The embodiments disclosed below are for elaborating the manufacturing methods of the organic light emitting diode display panel **100** of the disclosure. However, the descriptions disclosed in the embodiments of the disclosure such as detailed manufacturing procedures are for illustration only, not for limiting the scope of protection of the disclosure. Detailed structures and processes may be modified or changed by one skilled in the art after having the benefit of this description of the disclosure. Referring to FIGS. 4A-4C, FIGS. 4A-4C illustrate a process for manufacturing an organic light emitting diode display panel according to an embodiment of the present disclosure.

Referring to FIG. 4A, the first substrate **110** is provided, the first electrode **120** is formed on the first substrate **110**, and the organic light emitting layer **130** is formed on the first electrode **120**. The detailed description of processes of manufacturing additional components, such as thin film transistors and conductive lines, are omitted from the description of the above-mentioned steps.

Referring to FIG. 4B, the second electrode **140** is formed on the organic light emitting layer **130**. In the embodiment, the second electrode **140** is formed by such as a thermal evaporation process. In the embodiment, the first portion **141** and the second portion **143** of the second electrode **140** are formed in the same thermal evaporation process simultaneously. The ratios of the alkaline earth element to silver in the first portion **141** and in the second portion **143** are different.

In the embodiment, the first portion **141** and the second portion **143** are formed in the same thermal evaporation process. When the silver content in the first portion **141** is higher, in other words, the silver contents in the first portion **141** and in the second portion **143** are closer, the interface **140a** between the first portion **141** and the second portion **143** is more indefinite and less distinct, that is to say, the physical interface that can be observed by such as an electron microscopy is less clear. Nevertheless, for example, the first portion **141** and the second portion **143** are two stacked films, an area of the first portion **141** close to the organic light emitting layer

7

130 and an area of the second portion 143 close to the second substrate 150 still have different ratios of the alkaline earth element to silver.

Referring to FIG. 4C, the second substrate 150 is disposed on the second substrate 150. As such, the organic light emitting diode display panel 100 as shown in FIG. 40 (FIG. 2) is formed.

FIGS. 5A-5B illustrate a process of an organic light emitting diode display panel according to another embodiment of the present disclosure. Please refer to FIG. 4 and FIGS. 5A-5B.

First, the structure as shown in FIG. 4A is formed. Next, as shown in FIG. 5A, the first portion 141 of the second electrode 140 is formed on the organic light emitting layer 130. In the embodiment, the first portion 141 of the second electrode 140 is formed by such as a thermal evaporation process. The magnesium content in the first portion 141 is relatively high, and thus, an irregular structure as shown in FIG. 5A may be formed, and the first portion 141 has a surface of an irregular shape.

Next, as shown in FIG. 5B, the second portion 143 of the second electrode 140 is formed on the first portion 141. In the embodiment, the second portion 143 of the second electrode 140 is formed by such as a thermal evaporation process. The silver content in the second portion 143 is relatively high, and thus, the film formation is greater, such that the second electrode 140 can be formed with a flat surface. Moreover, the adhesion between the second electrode 140 and the organic light emitting layer 130 is increased.

Next, as shown in FIG. 4C, the second substrate 150 is disposed on the second electrode 140. As such, the organic light emitting diode display panel 100 as shown in FIG. 2 is formed.

While the disclosure has been described by way of example and in terms of the exemplary embodiment(s), it is to be understood that the disclosure is not limited thereto. On the contrary, it is intended to cover various modifications and similar arrangements and procedures, and the scope of the appended claims therefore should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements and procedures.

What is claimed is:

1. An organic light emitting diode display panel, comprising:

a first substrate;  
a second substrate;  
a first electrode disposed between the first substrate and the second substrate;

an organic light emitting layer disposed between the first electrode and the second substrate; and

a second electrode disposed between the organic light emitting layer and the second substrate, the second electrode comprising a first portion and a second portion, the first portion is located between the second portion and the first substrate,

wherein an irregular interface is located between the first portion and the second portion, the material of the second electrode comprises an alkaline earth element and silver, and the ratios of the alkaline earth element to silver in the first portion and in the second portion are different.

2. The organic light emitting diode display panel according to claim 1, wherein the alkaline earth element comprises magnesium (Mg) and calcium (Ca).

3. The organic light emitting diode display panel according to claim 2, wherein the first portion is formed of magnesium.

8

4. The organic light emitting diode display panel according to claim 2, wherein the first portion is formed from magnesium and silver, and magnesium is between 80% and less than 100%.

5. The organic light emitting diode display panel according to claim 2, wherein the first portion is formed from magnesium and silver, and magnesium is between 90% and less than 100%.

6. The organic light emitting diode display panel according to claim 2, wherein the second portion is formed from magnesium and silver, and magnesium is between larger than 0% and 90%.

7. The organic light emitting diode display panel according to claim 2, wherein the second portion is formed from magnesium and silver, and magnesium is between larger than 0% and 80%.

8. The organic light emitting diode display panel according to claim 2, wherein the second portion is formed of silver.

9. The organic light emitting diode display panel according to claim 1, wherein the ratio of the alkaline earth element in the first portion is larger than the ratio of the alkaline earth element in the second portion.

10. The organic light emitting diode display panel according to claim 1, wherein the ratio of a first thickness of the first portion to a second thickness of the second portion is 1:0.5-1:4.

11. An organic light emitting diode (OLED) display device, comprising:

a case; and

an organic light emitting diode display device, comprising:

a first substrate;

a second substrate;

a first electrode disposed between the first substrate and the second substrate;

an organic light emitting layer disposed between the first electrode and the second substrate; and

a second electrode disposed between the organic light emitting layer and the second substrate, the second electrode comprising a first portion and a second portion, the first portion is located between the second portion and the first substrate;

wherein an irregular interface is located between the first portion and the second portion, the material of the second electrode comprises an alkaline earth element and silver, and the ratios of the alkaline earth element to silver in the first portion and in the second portion are different.

12. The organic light emitting diode display device according to claim 11, wherein the alkaline earth element comprises magnesium (Mg) and calcium (Ca).

13. The organic light emitting diode display device according to claim 12, wherein the first portion is formed of magnesium.

14. The organic light emitting diode display device according to claim 12, wherein the first portion is formed from magnesium and silver, and magnesium is between 80% and less than 100%.

15. The organic light emitting diode display device according to claim 12, wherein the first portion is formed from magnesium and silver, and magnesium is between 90% and less than 100%.

16. The organic light emitting diode display device according to claim 12, wherein the second portion is formed from magnesium and silver, and magnesium is between larger than 0% and 90%.

17. The organic light emitting diode display device according to claim 12, wherein the second portion is formed from magnesium and silver, and magnesium is between larger than 0% and 80%.

18. The organic light emitting diode display device according to claim 12, wherein the second portion is formed of silver. 5

19. The organic light emitting diode display device according to claim 11, wherein the ratio of the alkaline earth element in the first portion is larger than the ratio of the alkaline earth element in the second portion. 10

20. The organic light emitting diode display device according to claim 11, wherein the ratio of a first thickness of the first portion to a second thickness of the second portion is 1:0.5-1:4. 15

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